In the United States Patent and Trademark Office

In re: Kafafi et al
Serial No.: 09/995,736 Examiner: E.M. Keaney
Filed: November 29, 2001 Art Unit: 2882
For: A Universal Host For RG Or RGB Emission In Organic Light Emitting Devices

Date: March 8, 2004

Declaration Under 37 C.F.R. 1.131(a)

Commissioner of Patents and Trademarks
Washington, D.C. 20231

Dear Sir:

Z.H. Kafafi, L.C. Picciolo and H. Murata, inventors in the above-identified patent application, declare as follows:

1. That prior to December 16, 1999, the invention claimed herein was conceived and reduced to practice in U.S.A by the inventors named above.

2. That the invention conceived and reduced to practice pertains to an organic light emitting diode (OLED) comprising, inter alia, a universal host that can be used for red, green and blue dopants for full color display; a hole transporting layer (HTL); electron transporting layer (ETL), which the universal host can also be; wherein HTL and ETL are on opposing of the universal host when the host is not serving as ETL; and anodes and cathodes on the outside of the HTL and ETL, respectively.

3. That under direction of above-named inventors, an experiment was carried out by Dr. H. Murata, one of the above-named inventors, which experiment contained the above-claimed components and, as evidenced by Exhibit A, attached hereto. Exhibit A includes pp. 132-146,

inclusive, of Dr. Murata's laboratory notebook dated prior to Dec. 16, 1999, i.e., the effective dates of the Picciolo et al and the Lin et al references.

The experiment, which was carried out and contemporaneously recorded on pp. 132-146 of Dr. Murata's laboratory notebook, starts on p. 132 where 4 OLED device structures are recorded with HTL layer 4,4-bis(1-naphthylphenylamino)biphenyl (NPB) was 500Å thick, hole blocking layer bathocuproine(2,9-dimethyl4,7-diphenyl-1,10-phenanthroline) (BC) was 100Å thick and 5,5'-(dimesitylboryl)2,2'-bithiophene (BMB-2T), which was 200Å thick and functioned as a universal host and as an electron injection layer or ETL. The universal host is bipolar and can function as ETL or HTL, providing blue emission. The thickness is same in the other device structures unless otherwise indicated. Also, the device structures #1- #4 are like a template for OLED devices #01- #09, described in succeeding pages. Device structure #1 corresponds to device #01; device structure #2 corresponds to devices #03 and #06; device structure #3 corresponds to devices #02, #04 and #05; and device structure #4 corresponds to devices #07, #08 and #09. In device structure #2, in BC, the X designates varying amounts which can be ascertained by reference to specific devices. In device structure #3, the green emitting material was N,N'-diethylquinacridon (DEQ) of differing content and the BC layer was 50Å thick. As noted. in device structure #4, the red emitting material was 6,13-diphenylpentacene (DPP) and its content in the composites was variable. Under "Composite" on p. 132, various composites are given though not so numbered, starting with #10, then #11, #12, #13 and #14, which correspond to those noted on p. 144. The composite #10 of BMB-2T:NPB was 50 mole % NPB and composite #11 of BMB-2T:BC was 50 mole % BC. In the other composites, mole % of the

dopants is given. It should be realized that these figures reflect the planned amounts whereas the actual amounts can be obtained from the actual composites on p. 144. At bottom of of p. 132 what is indicated is the quantities of substrates loaded into the evaporation chamber, i.e., nine ITO substrates for devices #01 - #09 and five SiO_2 substrates for composites #10 - #14.

On p. 133, deposition of NPB is disclosed with temperature setting of the furnace of 7.1 V at 8:20 AM which increased to 269.2 C when evaporation rate on substrate #1 was 30 Å/min and was continued for 16 minutes 40 seconds depositing a total of 518 Å. Deposition on substrates #2, #3, #4, #5, #6, #7, #8 and #10 was conducted as noted. The designation "W/BMB" indicates deposition of the NPB/BMB-2T composite.

On p. 134, deposition of BMB-2T is disclosed. The designation "I_{max}" denotes maximum current power on the furnace. The designation "<100>" denotes the setting temperature on the furnace at 8:20 AM which reached 52°C at 8:40 AM and 102°C at 9:45 AM. At 1:55 PM, deposition rate was set at 7.0 Hz/min which is about equivalent to 7.0 Å/min. At 3:42 PM, the designation "Flag DEQ was open" refers to the fact that the DEQ shutter was open and that deposition of BMB-2T on substrate #2 was probably contaminated with DEQ.

Page 135 shows deposition of DEQ. The designation "A.T" is a contraction for "auto tune" and "0.5" at 10:32 AM indicates the evaporation rate in Hz/min.

The upper portion of p. 136 describes preparation of DPP and pressuring the deposition chamber of BC_e which is continued to p. 137.

Page 138 shows deposition of Mg and Ag electrodes. Because of lack of adhesion on the part of Mg, the composite of 27/1 Mg/Ag was deposited as a cathode, ITO served as the anode.

At 11:15 AM, temperature in the Mg furnace was 370°C and Mg deposition was at 49 Hz/min whereas temperature in the Ag furnace was 930 °C and deposition was at 6.6 Hz/min. Pressure in the chamber was $1x10^{-7}$ Torr.

Page 139 shows characterization of device # 01 of 9 having the given composition. In the designation "1A1," the first "1" designates device #01, "A" represents a spot of spots A-D, and the second "1" designates scan number or measurement. Continuing with "1A1" and to its right, the number "0" represents starting voltage and the number "-15" represents ending voltage at spot "A." The purpose of this characterization was to determine threshold voltage to get light emission based on voltage-current requirements. If sufficient brightness from a device was obtained at high current and at low voltage, such a device was considered a good device since it does not consume much power. The important characterization of device #01 was that it produced very nice blue emission, as noted on p. 139.

Page 140 provides performance comparison of devices #02 and #03. It appears that absence of DEQ in device #03 resulted in brightness that is about one order of magnitude lower than in device #02, brightness emission of 130 v. 1066 cd/m^2.

Page 141 provides comparison between device, where 0.29% DEQ was present and device #05, where 0.58 % DEQ was present. Although there is a direct correlation in brightness emission with device #05 giving lighter brightness, the difference, i.e., 1073 v. 1001 cd/m^2 at 12 volts, is not that great for an increase in DEQ from 0.29 % to 0.58 %.

On p. 142, device #06 gave whitish emission of 160 cd/m^2 whereas device #07 gave whitish pink emission due to the presence of DPP. In both instances, brightness at 12 volts was

low.

Page 143 provides basis for concluding that 0,35 % DPP in the OLED device #08 gives higher brightness than device #09 with 0.17 % DPP or device #9 with 0.86 % DPP. At 12 V, brightness emission for devices #07, #08 and #09 was 216, 464 and 293, respectively.

Page 144 presents calculation of photoluminescence for samples #10-#14. The last column on the right, marked "ϕ_{PL}" gives yield for the samples. In this connection, sample #12 gave the best yield of 0.89 or 89 % efficiency, which is a very good result. Results given at the bottom 1/3 portion of p. 144 are not pertinent to the experiment on the universal host and should be ignored.

The declarants further state that the above statements were made with the knowledge that willful false statements and the like are punishable by fine and/or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that any such willful false statement may jeopardize the validity of this application or any patent resulting therefrom.

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